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Environmental Control Services

Environmental Control Programs

FILE: 997
DATE: July 28, 1987

Source Testing for Particulate Emissions From Power Boiler Unit 1 Thermal Generating Station, Selkirk, Manitoba 1986

Air Pollution Control,
Environmental Control Services,
Department of Environment and
Workplace Safety and Health.

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ABSTRACT

During February 1986 three particulate source emission tests were conducted on the breeching of boiler Unit 1 at Manitoba Hydro's Selkirk Thermal Generating Station, located in the Parish of St. Clements (East Selkirk), Manitoba. At that time the average concentration of particulate matter emitted from the 76 metre stack was 1.94 grams per dry standard* cubic metre (g/dscm) when corrected to 12 percent CO_2.

In 1986 the Selkirk Station was utilized for testing and training purposes only, rather than to supplement the capacity of Manitoba Hydro's hydraulic stations. Consequently as annual electrical power generation was well below the amount specified for Clean Environment Commission Order No. 1048 Clause 1(c), the particulate emission limit was not in effect for 1986.

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* temperature 25°C, pressure 760 mm Hg

INTRODUCTION

Manitoba Hydro's Selkirk Thermal Generating Station, located in East Selkirk, Manitoba, is capable of producing 132,000 kW of electrical power.

Since 1960 the station has supplemented Manitoba Hydro's hydraulic electrical generating capability. The station can be brought on line during emergencies, or when northern Manitoba water levels are low, and peak load demand exceeds the hydro-electric generating capacity of the rivers.

Two gas turbine units were added to the station in 1969 to provide 25,000 kW of extra capacity for emergencies and peak load demands. These units have an incredible short warm up time of 3 to 5 minutes from cold to full load.

Manitoba Hydro was granted Clean Environment Commission Order No. 1048 for the continued operation of Selkirk Thermal Generating Station complex on September 11, 1984.

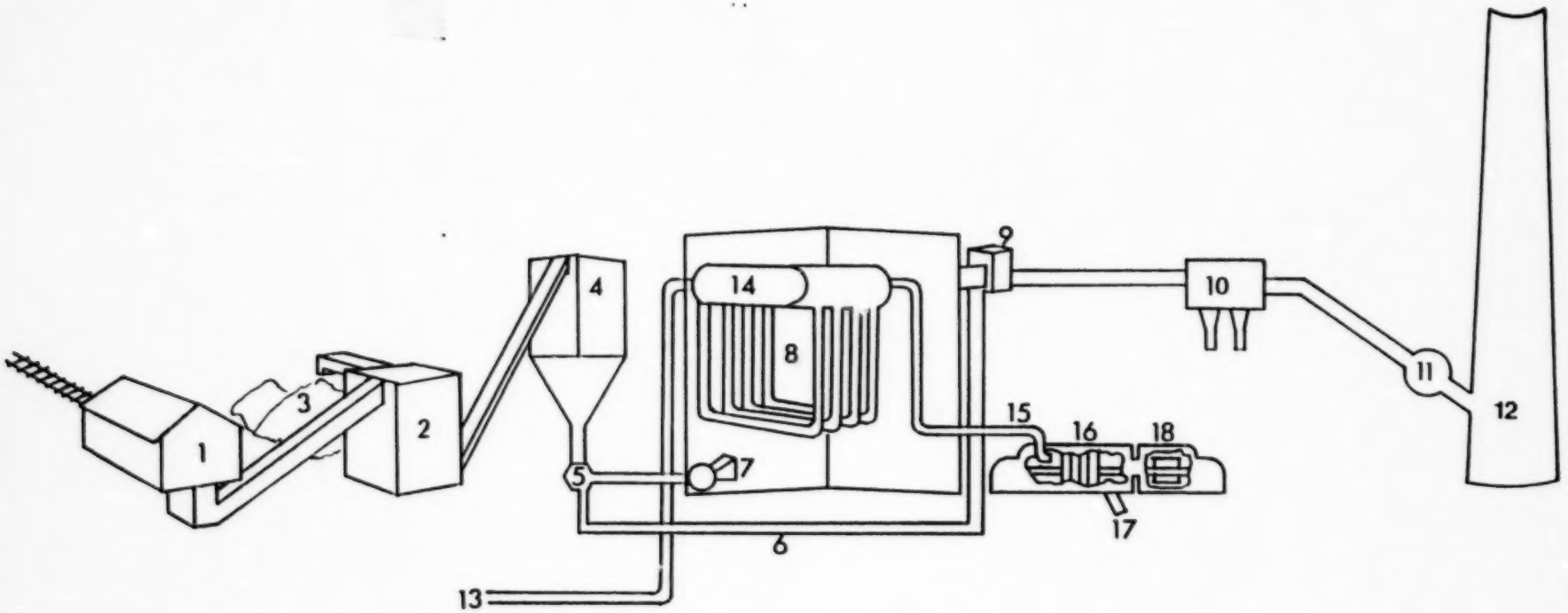
PROCESS DESCRIPTION

Thermal generation of electricity is a process where water is heated to produce steam which is fed to a steam turbine. A generator attached to the steam turbine is used to produce electrical energy. The basic system at Selkirk Thermal Generating Station is explained below and illustrated in Figure 1.

Lignite coal (0.5 percent average sulphur content) is shipped by railroad from Estevan, Saskatchewan to the unloading shed at the generating station where it is unloaded and falls through a floor grate. The coal is then conveyed to the crusher house where it is either stockpiled outside or crushed to a maximum diameter of 20 mm and sent to a coal bunker. Coal released from the bunker is automatically weighed, pulverized into a very fine powder, and then fed by pre-heated high velocity air into the boilers where it is burned.

Hot flue gases from the boiler combustion chambers are then fed into multiclone mechanical dust collectors which remove approximately 70 percent of the entrained fly ash. The flue gases then exit through a 76 m high reinforced concrete stack. The inside diameter at the top of the stack is 4.3 m. Ash from the dust collectors is transported to a special lagoon.

Two C. A. Parsons steam turbo generators are powered by high temperature and pressure steam from the boilers. The steam hits a series of blades attached to the turbine shaft causing it to rotate at



1. Unloading Shed
2. Crusher House
3. Coal Stockpile
4. Coal Hopper
5. Pulverizer
6. Air Line
7. Burner
8. Combustion Chamber
9. Air Preheater
10. Multiclones
11. Induced Draft Fan
12. Stack
13. Boiler Water Inlet
14. Boiler Drum
15. Steam Line
16. Steam Turbine
17. Steam Exhaust
18. Electrical Generator

FIGURE 1. BASIC COMPONENTS OF A THERMO-ELECTRIC GENERATING STATION

3600 rpm. Coupled to each turbine is an electrical generator capable of producing a maximum of 66,000 kW.

In 1969 two Brown Boveri 12,500 kW generator units were added to the station to produce extra capacity for emergency and peak power demands. A Pratt and Whitney JT3C-6 gas turbine engine is used to power each unit.

PROCESS SCHEDULE

Steam turbine generator Unit 1 was tested over a two day period during normal training conditions. Process information supplied by Manitoba Hydro can be found in tables 1 to 3.

Annual electrical power generation was well below 360,000 megawatts as the station was only utilized for training and testing purposes in 1986.

TABLE 1. UNIT 1 PRODUCTION DURING TEST 1.

DATE: 86 2 11	TURBINE LOAD			BOILER LOAD				SELKIRK GEN. STN.
TEST: 1						AIRHEATER OUTLET TEMPS.		
TIME	INDICATED TOTAL MW	TURBINE INTEGRATED	UNIT TRANSFORMER INTEGRATED	STEAM FLOW KG/SEC.	RELATIVE AIR FLOW KG/SEC.	A °C	B °C	O_2
12:15	60	17128.5	59525.9	67	68	133	137	5%
12:30	60.5	17130.0	59526.7	67	68	134	137	4.5%
12:45	60.8	17131.7	59527.5	67	68	135	139	4.4%
13:00	59.5	17133.1	59528.3	68	68	135	138	4.6%
13:15	60	17134.6	59529.1	66	68	136	140	4.7%
13:30	60.5	17136.0	59529.8	67	69	137	140	4.7%
13:45	62	17137.6	59530.6	69	71	139	140	5.0%
14:00	62	17139.1	59531.3	71	71	137	139	4.6%
	Sootblowing:							
	(1) 12:48 - IR's (wall blower; 14 per unit; blows for a duration of 3 minutes)							
	(2) 13:28 - IK's (retractable blower in superheater; 6 per unit; blows for							
	duration of 6 minutes)							

Turbine and Boiler Load Readings:

1. Please record every 15 minutes while tests are in progress.
2. For integrated meter readings, please estimate decimal figure from last dial. Readings will be like 53579.2 for turbine and 78606.8 for unit transformer.
3. Airheater outlet temperatures are points 7 and 8 on control room multipoint instruments.
4. For "test", please show whether velocity profile, or test 1, 2 or 3.
5. If sootblowing, please also show sootblowing steam flow.

TABLE 2. UNIT 1 PRODUCTION DURING TEST 2.

DATE: 86 2 11	TURBINE LOAD			BOILER LOAD				SELKIRK GEN. STN.
TEST: 2						AIRHEATER OUTLET TEMPS.		
TIME	INDICATED TOTAL MW	TURBINE INTEGRATED	UNIT TRANSFORMER INTEGRATED	STEAM FLOW KG/SEC.	RELATIVE AIR FLOW KG/SEC.	A °C	B °C	O_2
15:00	59.5	17145.2	59534.6	67.0	68.0	132	135	5.2%
15:15	59.5	17146.5	59535.2	67.5	68.5	132	134	5.0%
15:30	60.0	17148.0	59536.0	66.0	67.5	134	135	4.6%
15:45	58.7	17149.6	59536.8	65.0	66.5	133	136	4.5%
16:00	58.4	17151.1	59537.8	65.5	67.0	130	135	4.8%
16:15	58.2	17153.0	59538.9	67.0	65.0	132	135	4.8%
16:30	58.6	17154.4	59539.2	66.1	65.0	132	135	4.9%
	Sootblowing:							
	(1) 15:30 - G9B's (generating bank blowers; 8/unit; blows for duration of 40 seconds)							
	(2) 15:40 - AH's (air heater blowers 2/unit; blows for duration of 20 minutes)							

Turbine and Boiler Load Readings:

1. Please record every 15 minutes while tests are in progress.
2. For integrated meter readings, please estimate decimal figure from last dial. Readings will be like 53579.2 for turbine and 78606.8 for unit transformer.
3. Airheater outlet temperatures are points 7 and 8 on control room multipoint instruments.
4. For "test", please show whether velocity profile, or test 1, 2 or 3.
5. If sootblowing, please also show sootblowing steam flow.

TABLE 3. UNIT 1 PRODUCTION DURING TEST 3.

DATE: 86 2 12	TURBINE LOAD			BOILER LOAD				SELKIRK GEN. STN.
TEST: 3						AIRHEATER OUTLET TEMPS.		
TIME	INDICATED TOTAL MW	TURBINE INTEGRATED	UNIT TRANSFORMER INTEGRATED	STEAM FLOW KG/SEC.	RELATIVE AIR FLOW KG/SEC.	A °C	B °C	O_2
10:30	59	17198.0	59561.8	68	69	138	132	4.5%
10:45	59	17199.5	59562.4	67	68	137	135	4.5%
11:00	58	17201.1	59563.2	66	67	136	134	4.4%
11:15	59	17202.5	59564.0	66	67	133	134	4.4%
11:30	60	17203.9	59565.0	67.5	68.5	135	135	4.5%
11:45	58	17205.4	59565.8	64.5	65	135	135	4.5%
12:00	60	17206.9	59566.5	66.5	68	135	135	4.4%
	Sootblowing							
	(1) 10:15 - IK's (retractable blower in superheater; 6 per unit; blows for							
	duration of 6 minutes)							

Turbine and Boiler Load Readings:

- Please record every 15 minutes while tests are in progress.
- For integrated meter readings, please estimate decimal figure from last dial. Readings will be like 53579.2 for turbine and 78606.8 for unit transformer.
- Airheater outlet temperatures are points 7 and 8 on control room multipoint instruments.
- For "test", please show whether velocity profile, or test 1, 2 or 3.
- If sootblowing, please also show sootblowing steam flow.

TEST PROCEDURES

All sampling was conducted from four ports located vertically on the west side of the 84 inch by 131.5 inch rectangular Unit 1 breeching. The sampling locations were 50 feet (5.9 diameter equivalents) upstream and 1 foot (0.1 diameter equivalents) downstream respectively of the nearest flow disturbances. Five points were sampled along each traverse according to EPS Method A specifications. The sample points, located at 13.1, 39.5, 65.8, 92.1 and 118.4 inches respectively from the inside stack wall are depicted on a cross section of the breeching in Figure 2. Sampling intervals were three minutes per point.

Source emission testing was conducted according to EPS Method E. Figure 3 illustrates the particulate stack sampling train. The sample was drawn into a 0.249 inch nozzle, through a 10 foot stainless steel heated probe and into a miniature cyclone which removed particulate matter of greater than 10μ diameter. The sample was then passed through a Whatman 934 AH glass microfiber filter (supported by a porous fritted glass disc), which removed particulate matter of 0.3μ diameter and greater. Both the cyclone and the filter were heated to prevent moisture from condensing on the glassware. The sample was then passed through four 500 ml Greenburg-Smith impingers connected in series in an ice bath. The first, third and fourth impingers had modified straight tips while the second was of the standard design. The first and second impingers

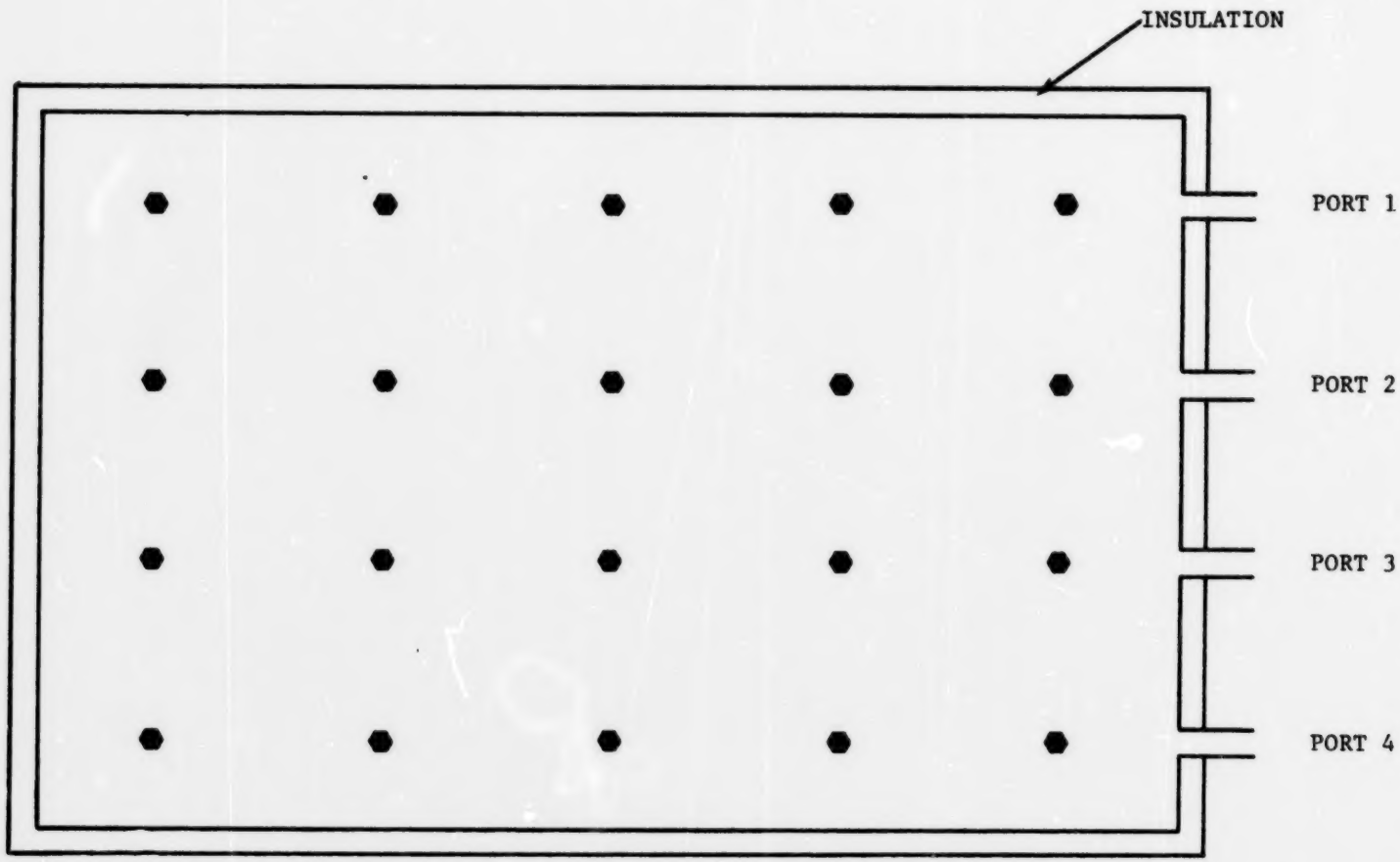


FIGURE 2. UNIT ONE BREECHING CROSS SECTION DEPICTING SAMPLE POINT LOCATIONS

● = SAMPLE POINT LOCATION

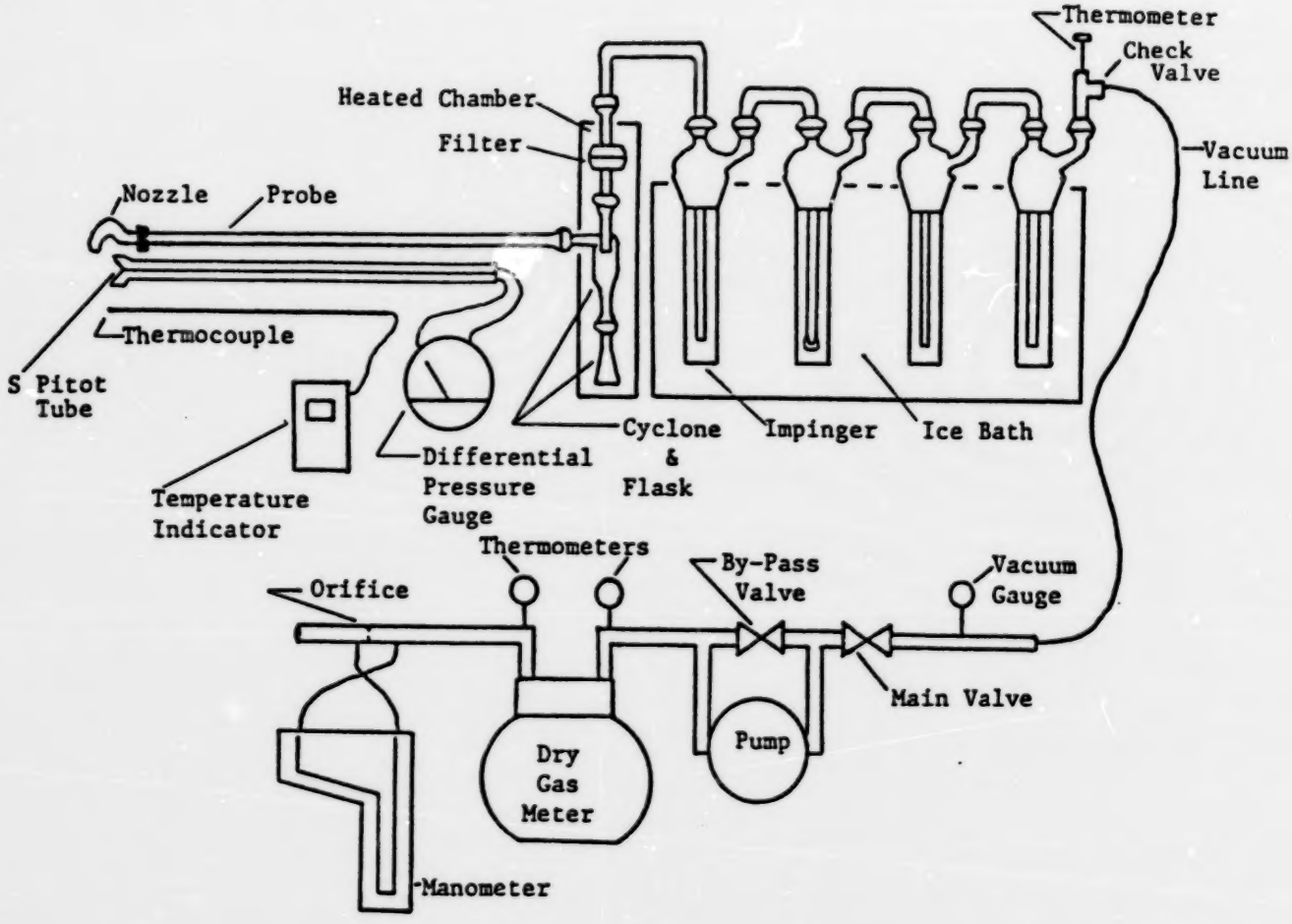


FIGURE 3. PARTICULATE STACK SAMPLING TRAIN

contained 100 ml of deionized water. The third impinger was initially empty while the fourth contained 200 grams of indicating silica gel to remove remaining moisture from the gas sample.

A Bendix Series 4500 Isokinetic Stack Sampler was used to extract the samples from the stack. Gas velocity in the stack was measured with an S-type pitot tube and a Dwyer Magnehelic Differential Pressure Gauge (range 0 to .50" H_2O, minor division 0.01" H_2O). Dry gas meter and pitot tube calibration data sheets are located in Appendix A. A Hays-Republic Model 621A Gas Analyzer was used to determine CO_2, O_2 and CO content of the stack gas. Stack temperature was measured by a K type thermocouple.

After sample recovery from the stack train, samples were submitted to the W. M. Ward Technical Services Laboratory for gravimetric analyses of particulates.

RESULTS

Important sampling parameters are summarized in Table 4. Refer to Appendices B and C respectively for velocity profiles and field data sheets.

Source emission data are summarized in Table 5. The particulate analytical reports are located in Appendix D.

TABLE 4: SUMMARY OF SAMPLING PARAMETERS

TEST NUMBER	1	2	3
SAMPLING DATE	Feb. 11/86	Feb. 11/86	Feb. 12/86
SAMPLING DURATION, min.	60	60	60
SAMPLE VOLUME AT METER CONDITIONS, m^3	0.6943	0.6868	0.6895
SAMPLE VOLUME AT STANDARD CONDITIONS, dscm*	0.6794	0.6561	0.6565
AVERAGE GAS METER TEMPERATURE, °C	30	37	37
ORIFICE PRESSURE DROP, mm H_2O	15.14	14.45	14.68
BREECHING STATIC PRESSURE, mm H_2O	-241.3	-241.3	-241.3
AVERAGE BREECHING TEMPERATURE, °C	127	125	125
AVERAGE BREECHING VELOCITY, m/s	9.3	9.1	9.3
ISOKINETIC FACTOR, %	103.3	100.6	101.1

*Standard Conditions are 25°C and 760 mm Hg

TABLE 5: SOURCE EMISSION SUMMARY

TEST NUMBER		1	2	3	AVERAGE
BREECHING GAS COMPOSITION DRY BASIS,	CO_2, % BY VOLUME	13.0	14.0	13.7	-
	O_2, % BY VOLUME	8.0	9.0	8.0	-
BREECHING GAS MOISTURE, % BY VOLUME		14.8	13.0	13.9	-
Ms**, g/g-mole		28.56	28.96	28.77	-
AVERAGE BREECHING GAS VOLUMETRIC FLOW RATE, dscm/h		146,056	147,033	146,889	146,659
CONCENTRATION OF PARTICULATE IN BREECHING GAS, g/dscm:	AT STACK CO_2	2.14	2.35	2.10	2.20
	AT 12% CO_2	1.97	2.02	1.84	1.94
EMISSION RATE OF PARTICULATE, kg/h		312	346	309	322

** Molecular Weight of the Stack Gas on a Wet Basis

DISCUSSION

Fly ash released from coal fired boilers may be either partially oxidized organic matter or noncombustible inorganic contaminants in the fuel. Other contaminants, such as sulphur, are released mainly as gaseous oxides and hence are not collected during a particulate test. In thermal plants where no particulate control devices are installed approximately 80 percent of the fly ash is entrained in the flue gas and subsequently emitted to the atmosphere. High emission rates necessitate some form of particulate collection device.

The high concentration of particulate matter emitted from Selkirk Generating station is mainly due to the dust collection system utilized. The multiclones at the Selkirk plant have a typical efficiency of approximately 70 percent. Boilers at new coal burning thermal generating stations utilize electrostatic precipitators which have a particulate collection efficiency of approximately 99 percent.

CONCLUSION

The results of the three source emission tests indicated the average concentration of particulate matter at the Unit 1 Breeching was 1.94 g/dscm when corrected to 12 percent CO_2.

Particulate testing indicated emissions were higher than the limit of 0.57 grams/dscm (corrected to 12% CO_2) stipulated in clause 1(c) of Clean Environment Commission Order No. 1048. However as annual electrical power generation was less than the 360,000 megawatt hours specified for the implementation of Clause 1(c), the Selkirk Thermal generating Station was not in violation of the Order.

SELECTED BIBLIOGRAPHY

1. Standard Reference Methods For Source Testing: Measurement Of Emission Of Particulates From Stationary Sources. Ottawa, Ont: Environment Canada, Environmental Protection Service, 1974 (Report EPS 1-AP-74-1).

APPENDIX A: EQUIPMENT CALIBRATION DATA

DRY GAS METER & ORIFICE METER CALIBRATION SHEET

Lab No 24168

Dry Gas Meter S/N Bendix 711030

Atmospheric Pressure 29.33 in hg or 745.0 mm hg

Ambient Temperature 20.6 °C

Calibrated re Large Wet Test Meter

Calibrated by Jim Pechaprich & Kevin Reese

Date 10 Oct 95

Manometer Orifice ΔH (in. H_2O)	W.T.M. Volume Vw ($Ft.^3$)	Dry Gas Meter Reading Initial ($Ft.^3$)	Dry Gas Meter Reading Final ($Ft.^3$)	D.G.M. Volume Vd ($Ft.^3$)	Temperature W.T.M. Tw (°F.)	Temperature W.T.M. Tw (°C.)	Temperature D.G.M. Ti (°F.)	Temperature D.G.M. To (°F.)	Time t (Min.:Sec.)	Time t (Min.)	W.T.M. Manometer Δm (in. H_2O)	Partial Pressure Ps (mm. Hg)	W.T.M.:D.G.M. Ratio γ (—)	$\sqrt{}$ (—)	Flowrate Q C.F.M. Qm ($Ft.^3$/min.)
0.508	4.0	799.924	803.943	4.022	68.6	20.3	101	77	10:15.82	10.2637	0.30	17.864	1.0041	0.5665	0.3856
0.505	4.0	804.943	808.950	4.032	68.6	20.3	103	79	10:17.75	10.2958	0.45	17.864	1.0069	0.5658	0.3857
0.503	4.5	810.506	815.055	4.549	68.6	20.3	104	81	11:36.06	11.6010	0.45	17.814	1.0068	0.5658	0.3846
1.03	4.0	817.086	821.143	4.057	68.7	20.4	101	83	7:09.16	7.1527	0.56	17.974	1.0006	0.8105	0.5583
1.03	4.0	822.153	826.215	4.062	68.7	20.4	101	83	7:09.80	7.1633	0.50	17.974	0.9995	0.8105	0.5575
1.03	4.5	827.232	831.820	4.588	68.7	20.4	101	84	8:04.80	8.0800	0.51	17.974	0.9964	0.8113	0.5571
1.53	5.0	835.896	841.008	5.112	68.7	20.4	110	85	7:18.39	7.3065	0.62	17.974	1.0011	0.9891	0.6847
1.54	5.0	842.534	847.651	5.117	68.7	20.4	111	85	7:18.34	7.3057	0.56	17.974	1.0011	0.9923	0.6849
1.55	5.0	848.674	853.797	5.123	68.7	20.4	112	86	7:18.72	7.3120	0.49	17.974	1.0019	0.9964	0.6856
2.06	5.0	856.368	861.506	5.138	68.7	20.4	115	87	6.2497	6.4162	0.54	17.974	1.0012	1.1490	0.7817
2.09	5.0	862.528	867.676	5.148	68.7	20.4	115	87	6:23.57	6.3928	0.67	17.974	0.9988	1.1573	0.7842
2.10	5.0	868.189	873.335	5.146	68.7	20.4	114	87	6:23.66	6.3943	0.64	17.974	0.9984	1.1601	0.7841

Linear Regression: Intercept (b) 0.0182

Slope (K) 0.6619

Coefficient of Determination (r^2) 0.9991

$\overline{\gamma}$ = 1.0003 ± 0.0033

ΔH@ = 2.0976

Comments:

#245 Rev. 8/23/93 JP/cm

DRY GAS METER & ORIFICE METER CALIBRATION SHEET

Lab No. 24168 2½

Dry Gas Meter S/N Bonder 711030

Atmospheric Pressure 29.33 in. Hg or 745.0 mm Hg

Ambient Temperature 20.6 °C

Calibrated re Large Wet Test Meter

Calibrated by Jim Fitzpatrick & Kevin Reese

Date 10 Oct 85

Manometer Orifice ΔH (in. H_2O)	W.T.M. Volume Vw ($Ft.^3$)	Dry Gas Meter Reading Initial ($Ft.^3$)	Dry Gas Meter Reading Final ($Ft.^3$)	D.G.M. Volume Vd ($Ft.^3$)	Temperature W.T.M. Tw (°F.)	Temperature W.T.M. Tw (°C.)	Temperature D.G.M. Ti (°F.)	Temperature D.G.M. To (°F.)	Time t (Min.:Sec.)	Time t (Min.)	W.T.M. Manometer Δ n (in. H_2O)	Partial Pressure Ps (mm. Hg)	W.T.M.:D.G.M. Ratio γ (—)	$\sqrt{\ }$ (—)	Flowrate @ S.T.P. Qm ($Ft.^3$/min.)
2.53	6.0	878.432	884.159	6.177	68.6	20.3	115	88	1:58.78	6.9797	0.67	17.864	0.9990	1.2738	0.8629
2.55	6.0	885.297	891.880	6.183	68.6	20.3	115	88	6.58.90	6.9817	0.61	17.864	0.9982	1.2788	0.8627
2.55	6.0	893.944	900.131	6.187	68.6	20.3	115	88	6.59.23	6.9872	0.78	17.864	0.9991	1.2788	0.8617
3.05	6.0	904.249	910.430	6.181	69.1	20.3	116	88	6.24.95	6.4158	0.83	17.864	0.9976	1.3977	0.9371
3.04	6.0	911.461	917.647	6.186	68.6	20.3	116	89	6.25.12	6.4187	0.82	17.864	0.9977	1.3967	0.9385
3.05	6.0	918.676	924.865	6.189	68.6	20.3	116	89	6.25.14	6.4190	0.83	17.864	0.9972	1.3989	0.9384

Linear Regression: Intercept (b) 0.0182

Slope (K) 0.6619

Coefficient of Determination (r^2) 0.9991

$\overline{\gamma}$ = 1.0003 ± 0.0033

$\Delta H@$ = 2.0976

Comments:

#245 Rev. 9/29/83 JP/cm

S-TYPE PITOT TUBE CALIBRATION

PROBE SIZE (ft) 10 CALIBRATION # 85 - 2

PROBE LINER SS DATE March 12, 1985

PROBE MANUFACTURER RAC AMBIENT TEMP. (°C) 20.1

TIP SIZE (inches) 0.250

STACK THERMOCOUPLE ☒ PRESENT

☐ ABSENT

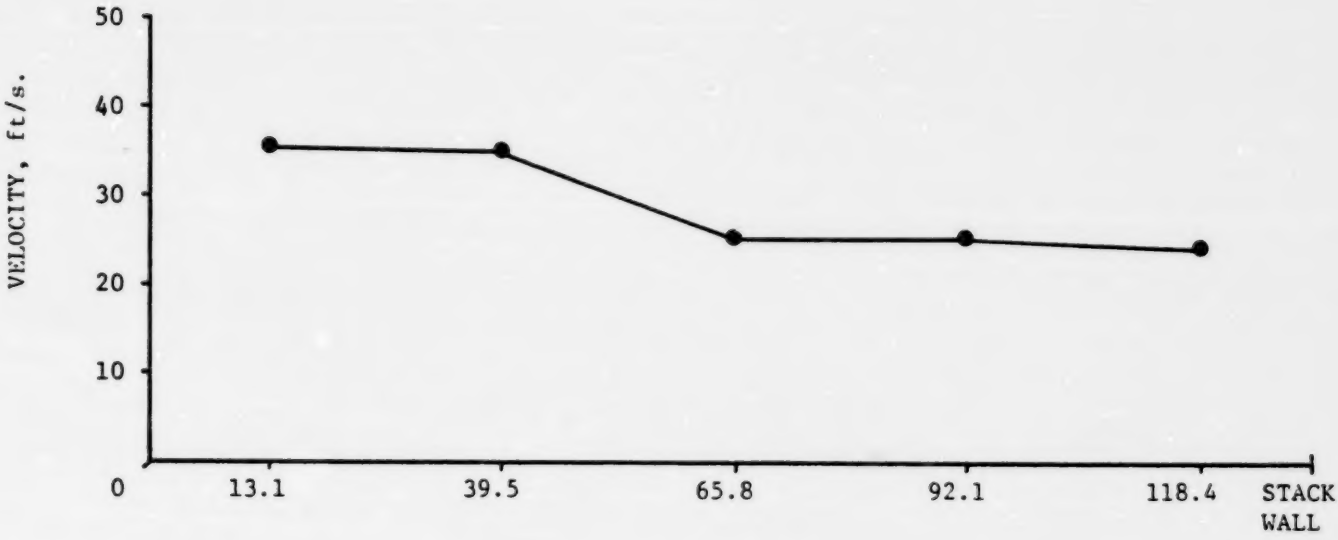
HP 97 INPUT/OUTPUT

Temp	20.1	°C		3.10	Δ p (std)	7.50	Δ p (std)
Bar. Press	28.99	In. Hg		37.620852		58.516510	
Scale Factor	0.1			4.68	Δ p (s-pitot)	10.78	Δp(s-pitot)
				0.811841		0.832021	
				37.628737		58.528773	
	0.60	Δ p (std)		4.18	Δ p (std)	9.88	Δ p (std)
Tunnel Velocity	16.550968	ft/sec		43.685361		67.162408	
	0.89	Δ p (s-pitot)		6.14	Δ p (s-pitot)	14.16	Δp(s-pitot)
Cp, at this	0.819018	velocity		0.823032		0.833220	
Tunnel Velocity	16.554437	(using Cp)		43.694516		67.176483	
	1.45	Δ p (std)		5.20	Δ p (std)		
	25.729526			48.724732			
	2.23	Δ p (s-pitot)		7.62	Δ p (s-pitot)	0.820046	Cp (ave)
	0.804349			0.824019		0.010984	Std. Dev.
	25.734918			48.734943		8	Deg. of Freedom
	2.29	Δ p (std)		6.31	Δ p (std)		
	32.334453			53.673815		2.306	± .05
	3.52	Δ p (s-pitot)		9.15	Δ p (s-pitot)	0.811603	Low Cp
	0.804562			0.828356		0.820046	Mean Cp
	32.341230			53.685063		0.828490	High Cp

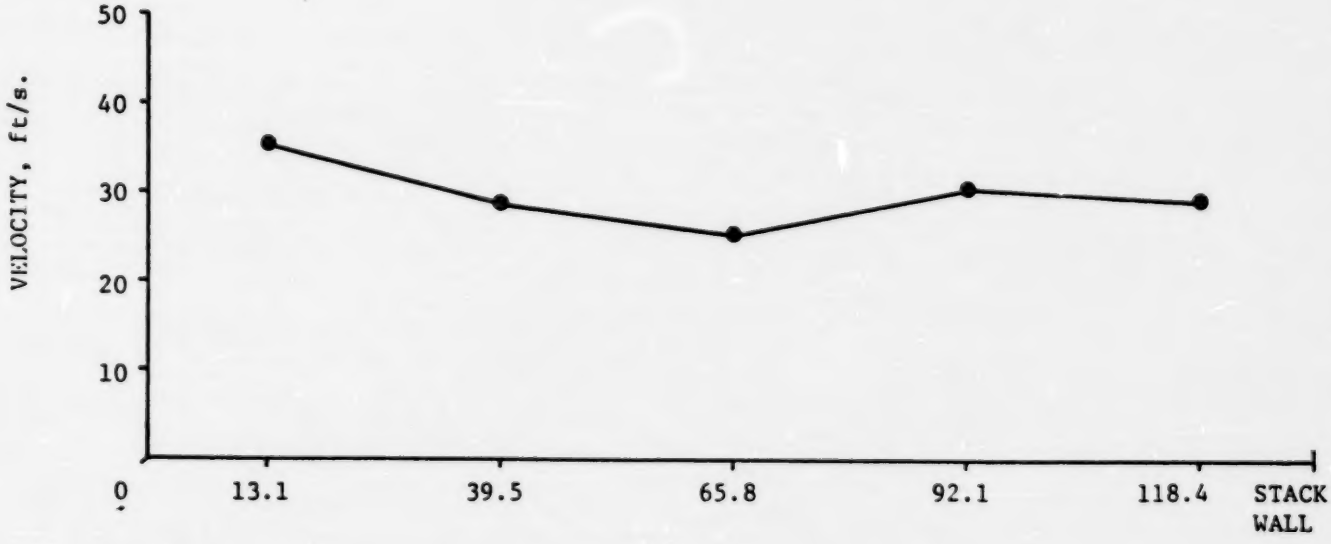
rev. 82-01

APPENDIX B: VELOCITY PROFILES

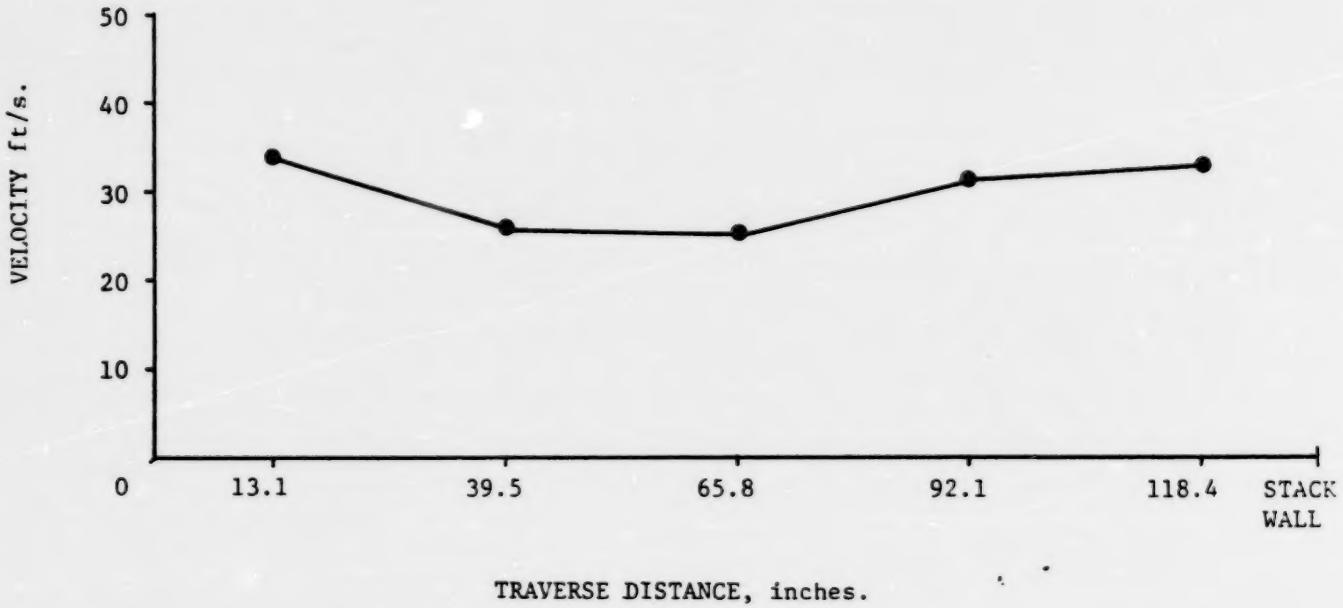
GRAPH 1 . VELOCITY PROFILE OF TEST 1 . FIRST PORT.



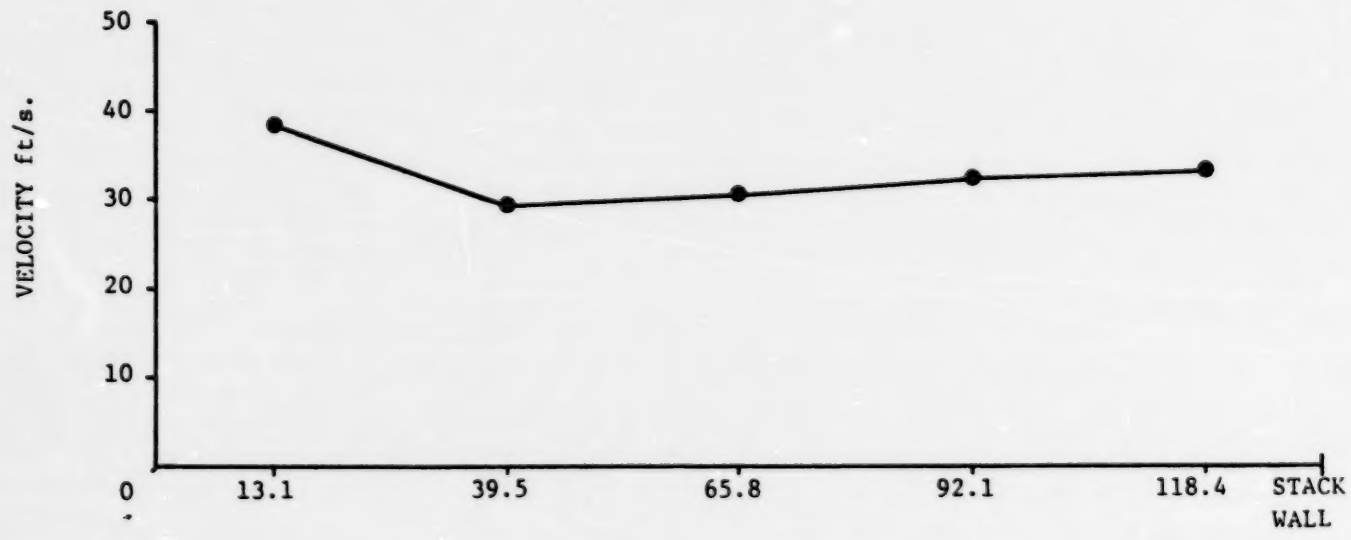
GRAPH 2 . VELOCITY PROFILE OF TEST 1 . SECOND PORT.



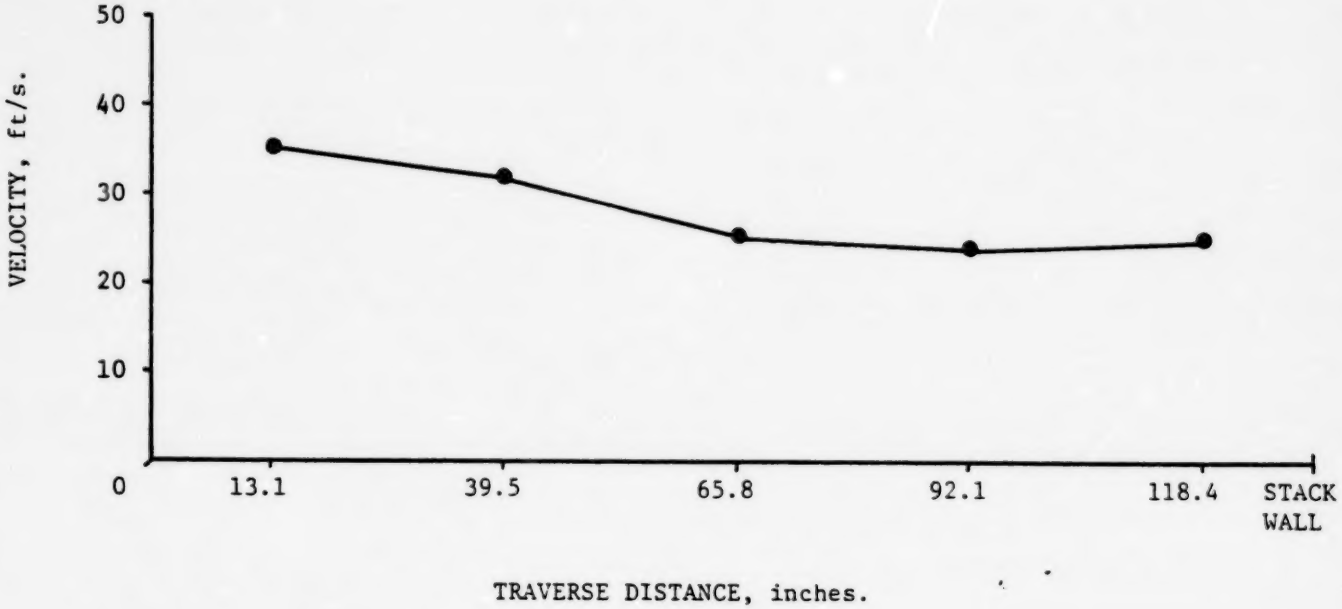
GRAPH 3 . VELOCITY PROFILE OF TEST 1 . THIRD PORT.



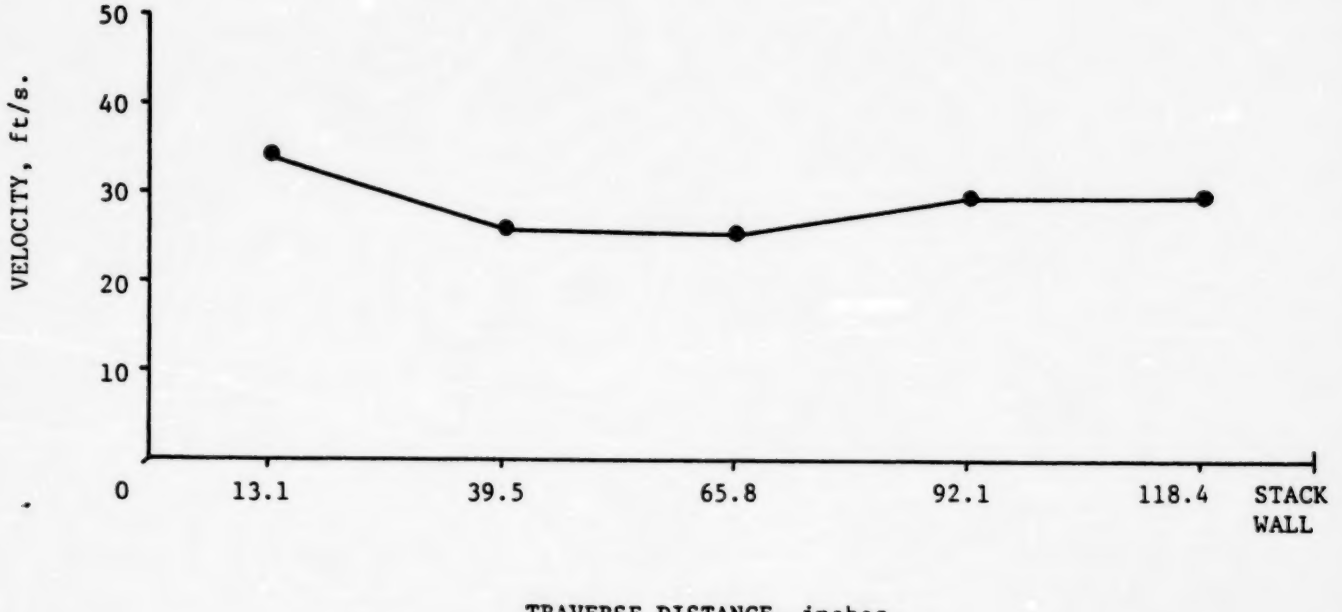
GRAPH 4 . VELOCITY PROFILE OF TEST 1 . FOURTH PORT.



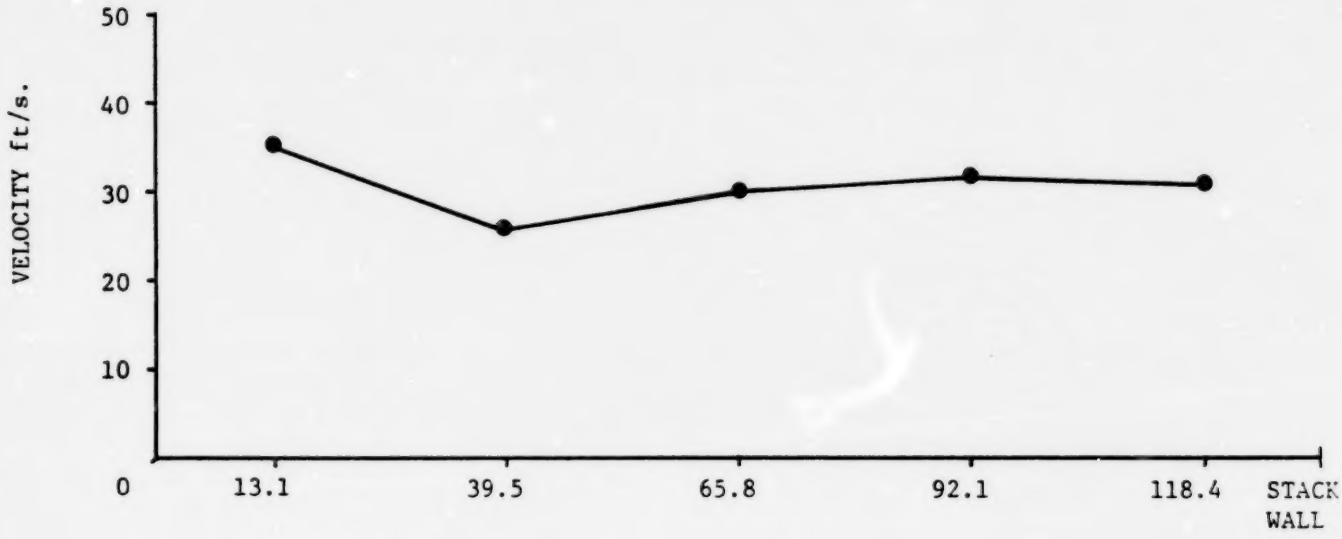
GRAPH 5 . VELOCITY PROFILE OF TEST 2 . FIRST PORT.



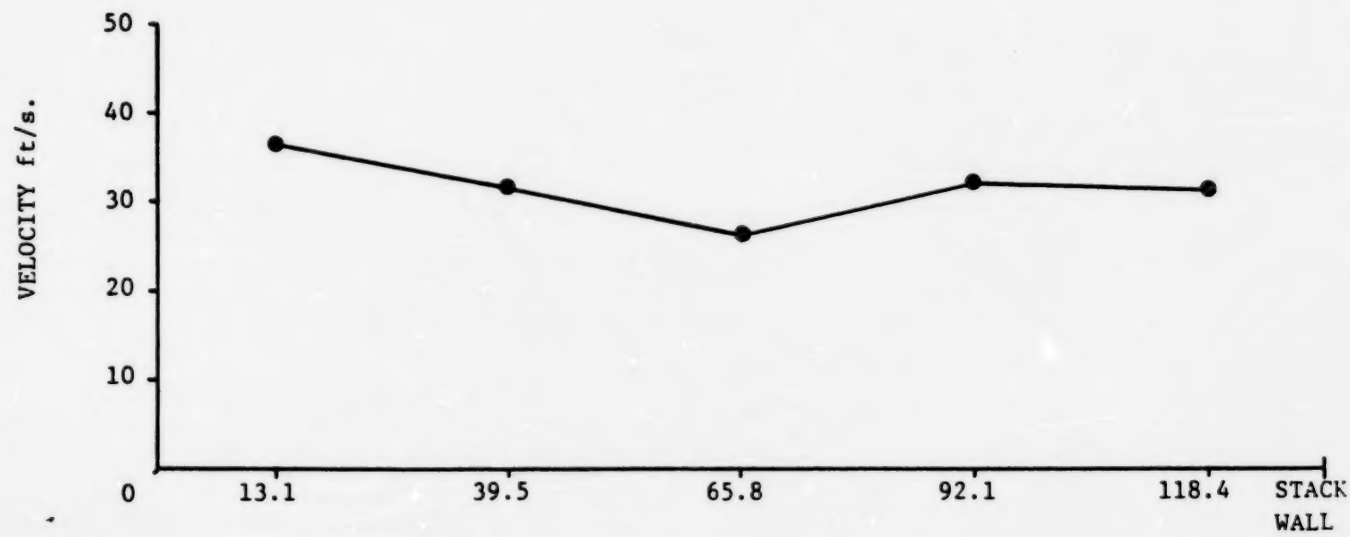
GRAPH 6 . VELOCITY PROFILE OF TEST 2 . SECOND PORT.



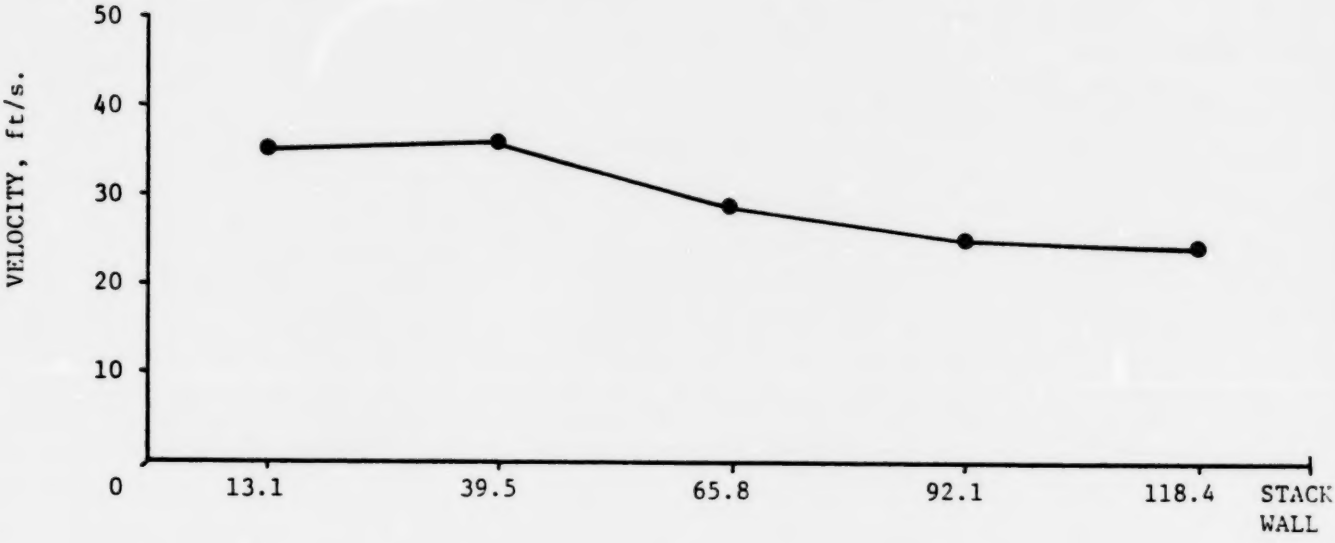
GRAPH 7. VELOCITY PROFILE OF TEST 2. THIRD PORT.



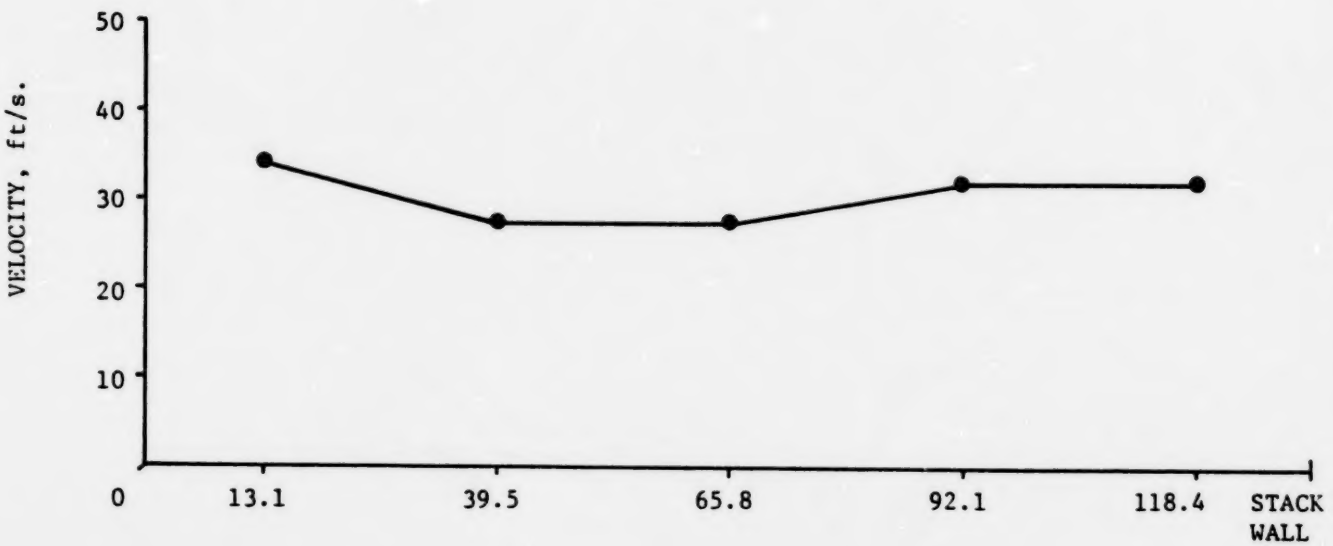
GRAPH 8. VELOCITY PROFILE OF TEST 2. FOURTH PORT.



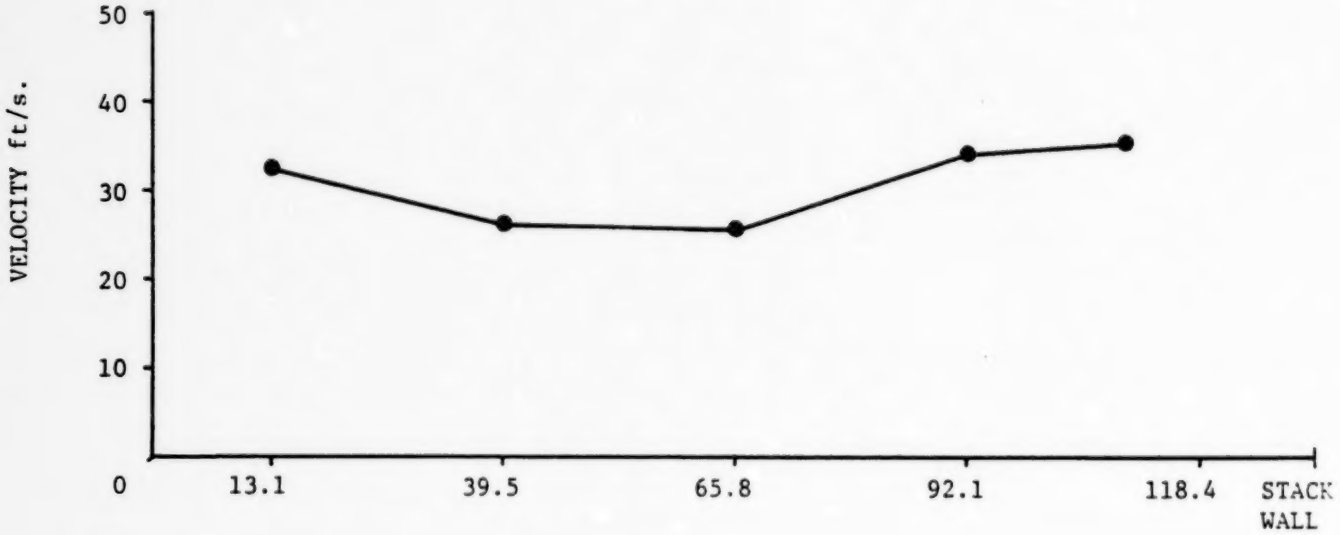
GRAPH 9 . VELOCITY PROFILE OF TEST 3 . FIRST PORT.



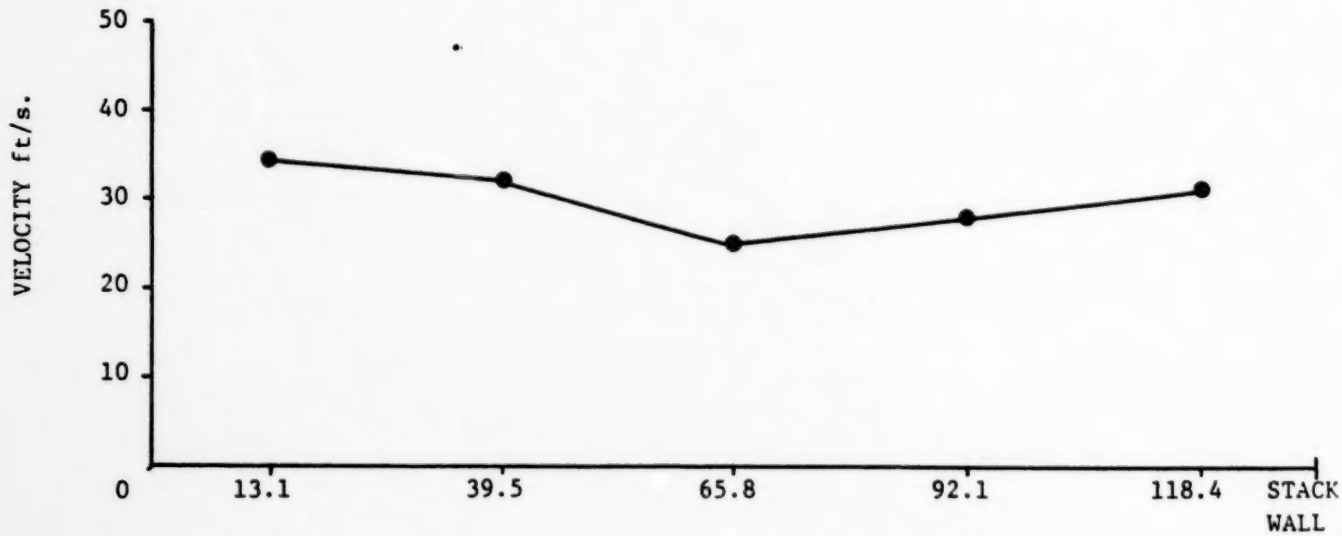
GRAPH 10 . VELOCITY PROFILE OF TEST 3 . SECOND PORT.



GRAPH 11 . VELOCITY PROFILE OF TEST 3 . THIRD PORT.



GRAPH 12 . VELOCITY PROFILE OF TEST 3 . FOURTH PORT.



APPENDIX C: FIELD DATA SHEETS

FIELD DATA SHEET

Plant SELKIRK GENERATING STATION Location SELKIRK, Manitoba

Stack UNIT #1 Breeching Test number 1 Date February 11, 1987

Ambient temperature (°F) - Barometric pressure (in. Hg) 29.48 Time 12:25 P.M. to 1:55 P.M.

Nozzle diameter (in.) 0.249 Probe length/type 10 ft./stainless steel Stack static pressure (in. H_2O) -9.5

Probe temperature (°F) ave. 244 Filter holder temperature (°F) ave. 233 Leak check 0.003 CFM @ 15 " Hg Vacuum

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. H_2O	Isokinetic factor, %
						Inlet	Outlet			
1 - 1	0	256	1.468	0.30	0.804	84	78	69	5	108.1
2	3	263	1.289	0.29	0.762	92	78	69	5	96.5
3	6	263	1.084	0.15	0.395	96	78	69	4	112.3
4	9	261	0.831	0.15	0.395	99	78	69	4	85.6
5	12	259	0.946	0.14	0.370	101	79	69	4	100.5
2 - 1	15	257	1.435	0.30	0.808	95	85	69	5	104.1
2	18	262	1.184	0.20	0.531	100	85	69	5	105.1
3	21	261	1.010	0.15	0.400	104	84	69	4	103.0
4	24	260	1.225	0.22	0.588	107	84	69	4	103.0
5	27	260	1.179	0.20	0.532	109	85	69	4	103.6
Average or total										

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. Hg	Isokinetic factor, %
						Inlet	Outlet			
3 - 1	30	260	1.406	0.28	0.751	104	88	69	4	104.5
2	33	261	1.065	0.16	0.430	108	88	69	4	104.6
3	36	262	1.005	0.15	0.402	108	88	69	4	101.9
4	39	260	1.276	0.23	0.618	112	88	69	5	104.1
5	42	258	1.359	0.26	0.703	114	89	69	5	104.0
4 - 1	45	263	1.600	0.35	0.947	106	92	69	6	106.3
2	48	261	1.240	0.20	0.544	108	92	69	6	108.5
3	51	266	1.243	0.22	0.591	111	91	69	5	104.0
4	54	264	1.307	0.24	0.643	112	89	69	5	102.5
5	57	261	1.365	0.26	0.702	115	91	69	5	104.3
Average or total	60	261	24.517	0.22	0.596	-	-	-	-	103.3

FIELD DATA SHEET

Plant SELKIRK GENERATING STATION Location SELKIRK, MANITOBA

Stack UNIT #1 Breeching Test number 2 Date February 11, 1987

Ambient temperature (°F) - Barometric pressure (in. Hg) 29.48 Time 3:10 P.M. to 4:32 P.M.

Nozzle diameter (in.) 0.249 Probe length/type 10 ft./stainless steel Stack static pressure (in. H_2O) - 9.5

Probe temperature (°F) ave. 246 Filter holder temperature (°F) ave. 248 Leak check 0.001 CFM @ 15 " Hg Vacuum

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. H_2O	Isokinetic factor, %
						Inlet	Outlet			
1 - 1	0	254	1.464	0.30	0.788	110	92	69	5	102.4
2	3	258	1.327	0.25	0.657	112	92	69	5	101.7
3	6	258	1.045	0.16	0.420	114	93	69	4	99.8
4	9	255	0.951	0.14	0.369	114	93	69	4	96.8
5	12	253	1.032	0.16	0.422	114	92	69	4	98.4
2 - 1	15	260	1.375	0.38	0.730	108	92	69	5	100.3
2	18	257	1.066	0.16	0.420	106	90	69	4	102.7
3	21	257	1.000	0.15	0.393	110	91	69	4	99.3
4	24	255	1.174	0.20	0.526	113	91	69	4	100.4
5	27	253	1.176	0.20	0.527	114	91	69	4	100.6
Average or total										

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. Hg	Isokinetic factor, %
						Inlet	Outlet			
3 - 1	30	260	1.442	0.30	0.782	100	90	69	5	102.5
2	33	260	1.051	0.16	0.417	105	90	69	4	101.8
3	36	259	1.221	0.22	0.574	110	90	69	4	100.2
4	39	257	1.303	0.25	0.654	112	90	69	5	99.9
5	42	257	1.305	0.24	0.627	112	90	69	5	102.3
4 - 1	45	260	1.501	0.32	0.834	92	90	69	5	104.0
2	48	259	1.278	0.24	0.626	100	88	68	4	101.7
3	51	259	1.014	0.16	0.416	102	88	68	4	98.5
4	54	258	1.299	0.24	0.624	103	88	68	4	103.0
5	57	256	1.227	0.22	0.575	105	88	69	4	101.3
Average or total	60	257	24.251	0.22	0.569	-	-	-	-	100.6

FIELD DATA SHEET

Plant SELKIRK GENERATING STATION Location SELKIRK, MANITOBA

Stack UNIT #1 Breeching Test number 3 Date February 12, 1987

Ambient temperature (°F) - Barometric pressure (in. Hg) 29.37 Time 10:36 A.M. to 12:02 P.M.

Nozzle diameter (in.) 0.249 Probe length/type 10 ft./stainless steel Stack static pressure (in. H_2O) - 9.5

Probe temperature (°F) ave. 261 Filter holder temperature (°F) ave. 251 Leak check 0.001 CFM @ 15 " Hg Vacuum

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. H_2O	Isokinetic factor, %
						Inlet	Outlet			
1 - 1	0	260	1.449	0.30	0.774	90	84	69	4	105.0
2	3	261	1.416	0.30	0.774	100	83	69	4	102.0
3	6	262	1.155	0.20	0.514	100	83	69	4	101.7
4	9	260	0.963	0.15	0.386	102	84	69	4	97.6
5	12	257	0.940	0.14	0.362	104	84	69	4	98.2
2 - 1	15	255	1.381	0.28	0.730	104	86	69	5	101.7
2	18	253	1.106	0.18	0.470	104	87	69	4	101.3
3	21	255	1.104	0.18	0.471	108	87	69	4	101.1
4	24	255	1.274	0.24	0.627	111	88	69	4	100.6
5	27	254	1.293	0.24	0.629	114	89	69	5	101.6
Average or total										

Traverse point number	Clock time, start	Stack gas temperature, °F	Gas meter volume, cu. ft.	Velocity pressure, in. H_2O	Orifice pressure drop in. H_2O	Gas meter temperature, °F		Final impinger Temperature, °F	Pump vacuum in. Hg	Isokinetic factor, %
						Inlet	Outlet			
3 - 1	30	255	1.329	0.25	0.658	108	92	69	5	102.6
2	33	259	1.027	0.16	0.419	111	92	69	4	99.3
3	36	258	1.029	0.16	0.420	111	92	69	4	99.3
4	39	257	1.384	0.28	0.736	116	92	69	5	100.5
5	42	255	1.457	0.30	0.791	118	92	69	5	101.8
4 - 1	45	256	1.406	0.28	0.741	109	95	69	5	102.4
2	48	258	1.307	0.24	0.634	110	95	69	4	102.8
3	51	259	0.975	0.14	0.369	111	94	69	3	100.6
4	54	258	1.105	0.18	0.474	112	94	69	3	100.2
5	57	255	1.245	0.22	0.581	116	94	69	4	101.5
Average or total	60	257	24.345	0.22	0.578	-	-	-	-	101.5

APPENDIX D: ANALYTICAL REPORTS

W.M. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER: KEVIN REEVE
LOCATION: MB. HYDRO SELKIRK
REPORT TO: KEVIN REEVE
TEST #1 ER-1

L – Less than
G – Greater than

SAMPLE – ID From: Y 86 Sequent 02319 To: Y 86 Sequent 02321

Date Sampled: Y 86 M 02 D 11

Date Received: Y 86 M 02 D 14

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
2319	BOTTLE #1	TSP		0.07049	g	86.02.20
2320	BOTTLE #2	TSP.		0.02192	g	86.02.20
2321	FILTER #466	TSP.		0.07244	g	86.02.20

Chemist Signature _____ Date _____

WM. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER:	KEVIN REEVE
LOCATION	MB. HYDRO - SELKIRK
REPORT TO	KEVIN REEVE
	TEST #2

SAMPLE – ID

From: Y 86, Sequent 02322

To: Y 86, Sequent 02324

L – Less than
G – Greater than

Date Sampled: 86 02 19

Date Received: 86 02 19

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
2322	BOTTLE #1	TSP.		0.7524	g	86 02 20
2323	BOTTLE # 2	TSP.		0.0352	g	86 02 20
2324	FILTER # 467	TSP.		0.7612	g	86 02 20

Date

Chemist Signature

W.M. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER: KEVIN REEVE
LOCATION: MB. HYDRO - SELKIRK
REPORT TO:
TEST #3 RK-1

From SAMPLE – ID: Y 86 Sequent 2325
To: Y 86 Sequent 2327

L – Less than
G – Greater than

Date Sampled: 86 02 12
Date Received: 86 02 14

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
2325	BOTTLE #1	TSP		0.0701 4	g	86 02 20
2326	BOTTLE #2	TSP		0.0428	g	86 02 20
2327	FILTER # 468	TSP		0.6450	g	86 02 20

Chemist Signature _____ Date _____

WM. WARD TECHNICAL SERVICES LABORATORY CHEMICAL ANALYSIS FORM II

SUBMITTER: K. REEVE
LOCATION: —
REPORT TO: K. REEVE
(1)

SAMPLE – ID
From: Y — Sequent — —
To: Y 86 Sequent 0049

L – Less than
G – Greater than

Date Sampled: Y 86 M 09 D 26
Date Received: Y 86 M 10 D 10

Sample Number	Identification or Comments	Parameter	L/G	Value	Units	Date Analysed
408	BLANK IMPINGER WATER	TSP		0.0030	g	861013

Chemist Signature _____ Date _____